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Regional Studies of Time of Planting and Hill Spacing of Sweetpotatoes

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ANY DELAY beyond the earliest practicable frost-free planting date, as shown by the studies here reported, resulted in marked decreases in yields of sweetpotatoes. Late plantings also lowered the starch and carotene contents of No. 1 sweetpotatoes and resulted in longer and slenderer roots as compared with shorter and chunkier roots from early plantings. Close spacing reduced the size of the roots without markedly affecting the shape, the starch content, or the total yields. Close spacing thus did not compensate for the reduced yields of late plantings; and the influence of time of planting on yields was shown to be far greater than that of spacing.

Although much information is available on the effects of varying the spacing of sweetpotatoes upon yield, less work has been done on the influence of the time of planting on grade and yield and no studies have been noted on the combined influence of these two factors or their interaction with different varieties and under varying environmental conditions. The cooperative studies reported herein were undertaken because of the need throughout the Southern States for information

about the influence of hill spacing and time of planting, separately and in combination, upon yield, grade, shape, and starch and carotene contents.

IMPORTANCE OF SWEETPOTATOES

The sweetpotato (*Ipomoea batatas* (L.) Lam.) is the second most important vegetable crop in the United States, being exceeded in importance only by the potato (Irish). In recent years about 800,000 acres of land have been devoted to the growing of sweetpotatoes in this country principally for food and feed, producing crops worth 50 to 60 million dollars annually. Growing sweetpotatoes for industrial utilization is a new agricultural enterprise of increasing importance in the South. Because of its ready adaptability to certain processing requirements and its high food value as compared with many other foods, the sweetpotato has acquired new and added national prominence during the present war emergency. To help feed the Allied armies and the civilian populations of our allies, millions of pounds of dehydrated sweetpotatoes are being prepared annually because of their high carbohydrate and vitamin contents in relation to the units of shipping space required.

Millions of pounds of root starches have been imported in the past, chiefly from the East Indies. These supplies have been cut off by the war and domestic sources of root starches are desirable. This has led to an increased interest in the potential possibilities of the sweetpotato as a commercial domestic source of root starch. Sweetpotato starch has been found equal or superior to other root starches in the manufacture of certain adhesives, laundry starch, textile and paper sizings, and cosmetics and for use in baking and confectionery industries.

REVIEW OF LITERATURE

Many reports have been made of results of studies of the influence of hill spacing upon grade and yield of various varieties of sweetpotatoes grown under varying environmental conditions. Anderson and associates (*1*),[1] after many tests at several locations in Mississippi, recommended 12-inch spacing for the Porto Rico variety grown with a moderately high rate of fertilizer application. They recommended 12 to 18 inches for the Triumph variety when grown for starch manufacture. These recommended spacings were based on plantings not later than June 15. Beattie, Boswell, and McCown (*4*), working with the Porto Rico at Florence, S. C., found that among hill spacings of 6, 9, 12, and 15 inches, in rows 4 feet apart, the yield and percentage of the No. 1 grade remained practically constant. As the spacing increased, the yield and percentage of oversize roots increased and of the No. 2 grade (too small for No. 1) decreased, but insignificant differences occurred between spacings differing by less than 6 inches. In other studies they found that successive 2-week delays in planting from May 15 to July 15 resulted in successively lower yields for the respective plantings of about 30 bushels of No. 1 and of 50 bushels of total yield per acre. Delayed planting markedly decreased the yield and percentage of Jumbos (oversize) and increased the percentage of the No. 2 grade.

Woodard (*11*) conducted tests for 6 years on sandy soils at Tifton, Ga., with the Porto Rico variety spaced by 4-inch differences from 4 to 28 inches in rows 3½ feet apart. A uniform fertilizer treatment was given to all spacings. Woodard concluded that the yield of No. 1

[1] Italic numbers in parentheses refer to Literature Cited; p. 20.

sweetpotatoes was affected very little, although the total yields were considerably higher from the closer spacings. The greater yields resulted from greater amounts of the No. 2 grade and "strings" obtained from the closer spacings.

Miller and Kimbrough (*8*) found in experiments with 9-, 12-, 15-, 18-, and 20-inch spacings at Baton Rouge, La., that a greater yield of oversize roots was obtained from wider spacings on the more fertile soils. They obtained higher total yields and higher No. 1 yields from the 12-inch spacing. The 9-, 12-, and 15-inch spacings produced about the same yields of the No. 2 grade, which exceeded slightly the yields of No. 2 from the wider spacings. The soil used in their experiments was very fertile, producing nearly 400 bushels of No. 1 grade sweetpotatoes. Apparently, under the conditions of those experiments, the effect of wider spacing was to increase No. 1 grade at the expense of some of the No. 2's and to increase Jumbos at the expense of some of the No. 1's as well as to reduce the total and No. 1 yields. They recommended a 12-inch spacing for June 1 planting on Louisiana soils.

From 1925 to 1929 Price (*9*) planted Nancy Hall sweetpotatoes at State College, Miss., at 10-, 15-, 20-, 25-, 30-, and 35-inch distances in the row and graded the yield into marketable and unmarketable roots. His results showed that the closer the spacing from 10 to 20 inches the higher the yield of marketable sweetpotatoes. The 10-inch spacing made a 5-year average of 40 bushels more than did the 15-inch spacing and 48 bushels more than did the 20-inch spacing. The wider distances about equaled each other in yield. Price weighed representative sweetpotatoes from the various spacings and found that there was an average increase in their weight of nearly one-tenth of a pound for each increase of 5 inches in planting distance.

At the West Tennessee Experiment Station[2] tests for the period 1926 to 1931 with Nancy Hall planted at 6-, 12-, 18-, and 24-inch spacings in 3-foot rows at approximately 3-week intervals from the first week of May to the first week of July showed that 6 inches was not too close for high yields on fertile soil. At all the dates of planting, the 6-inch and 12-inch spacings made decidedly greater total yields than the wider spacings, but the 18-inch was not much better than the 24-inch. In 1931 the crop was graded into "eating" and "seed" sweetpotatoes, and the greatest yield of the "eating" grade was found on the 18-inch and 24-inch spaced plots at all planting dates.

Zimmerley (*12*), working with the Porto Rico variety on Sassafras loam at Norfolk, Va., compared 10-, 14-, 18-, and 22-inch spacings and found that in general the closer spacings gave the higher yields of marketable and total grades. The yields from the 10-inch spacing were not significantly greater, however, than from the wider spacings.

METHODS USED IN STUDIES

In 1940 there was initiated an extensive cooperative program of sweetpotato breeding and of research on their culture and propagation by the Bureau of Plant Industry, Soils, and Agricultural Engineering and seven State experiment stations.[3] The study herein reported represents one of six worked on by this group up to the time of this report. The sta-

[2] Private communication from B. D. Drain, Tennessee Agricultural Experiment Station, March 26, 1941, and L. A. Fister, West Tennessee Agricultural Experiment Station.

[3] Georgia Experiment Station, Georgia Coastal Plain Experiment Station, Louisiana Agricultural Experiment Station, Mississippi Agricultural Experiment Station, South Carolina Agricultural Experiment Station, Texas Agricultural Experiment Station, and Virginia Truck Experiment Station.

tions cooperating on this study have been the South Carolina Agricultural Experiment Station, the Georgia Experiment Station, the Mississippi Agricultural Experiment Station, and the Texas Agricultural Experiment Station. In South Carolina the work was done at the Edisto Experiment Station at Blackville; in Georgia, at the Georgia Experiment Station at Experiment; in Mississippi, in the vicinity of Laurel; and in Texas, at the Sweetpotato Investigations Laboratory at Gilmer. The Bureau of Plant Industry, Soils, and Agricultural Engineering participated in the planning, financing, and reporting of the work.

In these investigations five successive plantings with 8-, 12-, 16-, 24-, 32-, and 42-inch hill spacings were made of the Porto Rico (Unit 1 strain) and Triumph varieties, beginning soon after the average date of the last killing frost in the spring and extending by intervals of a length approximating one-twelfth of the normal growing season at each place. Thus the actual planting times and the interval between plantings varied from place to place, and because of the seasonal variations there was a few days' difference between the planting times in different years at any one location (table 1).

TABLE 1.—*Dates of successive plantings of sweetpotatoes at 4 locations in 3 years*

Location and year	Dates of successive plantings				
	First	Second	Third	Fourth	Fifth
Blackville, S. C.:					
1940	April 11	April 24	May 10	May 30	June 20
1941	April 10	April 29	May 17	June 6	June 24
1942	April 14	April 22	May 11	May 30	June 20
Experiment, Ga.:					
1940	April 16	May 7	May 27	June 17	July 9
1941	do	May 8	do	do	July 8
1942	do	May 6	May 26	June 16	July 10
Laurel, Miss.:					
1940	April 25	May 11	May 27	June 14	June 28
1941	April 15	May 8	May 29	June 21	July 12
1942	April 24	May 14	June 4	June 23	July 13
Gilmer, Tex.:					
1940	April 15	April 30	May 15	May 30	June 15
1941	April 25	May 13	May 27	June 14	June 24
1942	April 17	May 4	May 18	June 4	June 17

At each location where the investigations were carried on, the plots were located on soils that were representative of those usually planted to sweetpotatoes in the section. At Blackville the soil used in 1940 is classified as Marlboro sandy loam of good fertility. In 1941 Norfolk sandy loam of medium fertility was used, and in 1942 the same type of soil of poor to medium fertility was used. At Experiment the soils used for these experiments are classified as Cecil sandy clay loam and Cecil sandy loam. At Laurel, in 1940 the sweetpotatoes were planted on a terrace soil classified as Cahaba fine sandy loam, in 1941 on a terrace soil classified as Kalmia fine sandy loam, and in 1942 on an upland soil classified as Ruston fine sandy loam. At Gilmer each year they were planted on soil classified as Bowie fine sand.

The methods of land preparation and fertilization corresponded at each location with recommended local practices, but planting at all places was on medium high ridges 3½ feet apart. In all plots the soil was given the final preparation and the fertilizer was applied approximately a week before the transplanting of the plants. At Blackville a 4–8–8 fertilizer was used in 1940 at a rate of 1,000 pounds per acre,

applied in the drill before planting. In 1941, 1,000 pounds per acre of a 3–8–8 mixture was applied in the drill before planting. In 1942 the same amount and grade of fertilizer as were used in 1941 were applied, half before planting and half as a side dressing 3 weeks after planting. At Experiment the plots were fertilized with 800 pounds per acre of a 4–8–6 mixture, applied in the furrow and "bedded on" 10 days before planting. At Laurel 1,100 pounds of a 6–8–8 fertilizer was applied to all plots each year. It was applied in the furrow underneath the center of the row 10 days before planting in 1940, but it was side-placed in 1941 and 1942, 800 pounds on the day of planting and 300 pounds 3 weeks after planting. At Gilmer 600 pounds per acre of a 4–8–10 fertilizer was applied under the row 10 days before planting.

In all cases planting was done by the use of hand trowels and water was applied where necessary to establish good stands. Sufficient cultivation and hoeing were done to control weeds and to maintain a medium high ridge. Cultivation was discontinued as soon as the vines covered the rows enough to interfere.

All experiments were conducted on a split-split-plot Latin-square design of two-row plots 30 feet long exclusive of guard spaces. There were five replications of each spacing at each time of planting. The design of these experiments was kept the same at all four locations and in the 3 years so that it would be possible to combine the data for analysis. It is believed that information of wider applicability can be obtained by such uniform designs of experiments conducted in widely separated locations and in different years. All yield, starch, and other data were analyzed by Fisher's method (*6*) for the analysis of variance. Snedecor's tables of F values (*10*) were used in interpreting the significance of variance differences.

Harvesting of all plots was accomplished by methods that insured practically a complete removal of the sweetpotatoes from the soil. Specific methods of digging varied from place to place, but the rows were plowed up with an ordinary turning plow, with a common middlebuster, or with a middlebuster modified for sweetpotato digging by rod-wing attachments. The vines were either cut from the hills with hoes immediately before digging or cut in connection with digging by the use of a rolling colter adjusted on the plow beam, so that little or no cutting of the sweetpotatoes resulted.

The sweetpotatoes were sorted according to size only into Jumbo, No. 1, and No. 2 grades and culls, and each grade was weighed to the nearest one-tenth pound when the surface of the sweetpotatoes had dried.

At Blackville, Laurel, and Gilmer the studies included determinations of starch and moisture. For this purpose, 10 to 12 No. 1 roots were taken at random from each of the 8-, 16-, and 32-inch spacings of the Triumph variety from the first, third, and fifth plantings in the first, third, and fifth blocks. The sampling, accomplished within the same day as the harvesting, was effected by cutting out V-shaped longitudinal sections from each root of the sample by means of a power-driven sugar-beet sampling rasp. The roots were quickly washed with cool water and dried with towels before passing them through the rasp. The rasped material was then quickly weighed into 95-percent alcohol at room temperature in 2-ounce glass jars and tightly closed. Determinations of starch in these samples were made in 1 to 3 months at the United States Horticultural Field Station [4] at Meridian, Miss., by polariscopic methods (*3*).

[4] Acknowledgment is made of work by Belton Walters and J. L. Williams on these analyses.

At Laurel samples from 10 No. 1 roots were taken from the Porto Rico as described for starch determinations, except that the samples were preserved in alcohol that had been redistilled over potassium hydroxide and the carotene content was determined within 2 weeks by the method of Guilbert (7), using the photoelectric colorimeter.[5]

At Laurel and Gilmer length and diameter measurements were made of representative roots from the 8-, 16-, and 32-inch spacings of both varieties from the first, third, and fifth plantings and from the first, third, and fifth blocks each year to obtain information about the effect of spacing and time of planting upon the shape of sweetpotatoes.

WEATHER

Weather conditions, especially rainfall and temperature, have a marked influence upon stands and "growing-off" of sweetpotatoes. For this reason, the salient features of weather at the various locations where these experiments were carried on in each of the years from 1940 to 1942 are reviewed briefly.

In 1940 the temperature in the early part of the growing season was slightly low at Blackville and low at Experiment and Laurel. The early-season rainfall in 1940 was slightly low at Blackville, low at Experiment, high at Laurel, and very high at Gilmer. The midseason rainfall that year was low at Blackville, moderately low at Experiment, high at Laurel, and very high at Gilmer. The late-season rainfall was slightly low at Blackville, low at Experiment, very low at Laurel, and very high at Gilmer.

In 1941 the early-season temperatures were slightly high at Blackville, normal at Experiment, and low at Laurel; in the late season the temperatures were normal at Blackville and Experiment and low at Laurel. In the early part of the 1941 growing season the rainfall was very low at Blackville, low at Experiment, normal at Laurel, and very high at Gilmer. In midseason the rainfall was very high at Blackville, slightly low at Experiment, and very high at Laurel and Gilmer. In the late growing season that year rainfall was high at Blackville, low at Experiment and Laurel, and very high at Gilmer.

In 1942 the early-season temperatures were normal at Blackville, low at Experiment, and very low at Laurel. In midseason the temperatures were normal at Blackville and Experiment and low at Laurel. In the late season they were slightly high at Blackville and low at Experiment and Laurel. The early-season rainfall in 1942 was normal at Blackville, slightly high at Experiment and Laurel, and very high at Gilmer. In midseason the rainfall was slightly high at Blackville and Laurel, normal at Experiment, and very high at Gilmer. In the late season of 1942 rainfall was low at Blackville, slightly high at Experiment, and very high at Laurel and Gilmer.

The time rain occurs in relation to the time of planting is important, because of its effect upon establishment of stands. The second planting at Blackville in 1940 was made 9 days and the third one 25 days after a 0.17-inch shower, which fell on April 15. It was 10 days after the third planting before a good rain occurred. At Experiment no rains of as much as one-half inch occurred in April 1941 and 1942, but the first planting in 1940 at that location was followed 3 days later by a ¾-inch rain; in 1941 a ¾-inch rain preceded the second planting by 2 days.

[5] The help of Marvin Gieger, chemist, Mississippi Agricultural Experiment Station, in making these determinations is hereby acknowledged.

Those plantings should have "grown off" well. In 1942, however, no ½-inch rains occurred at Experiment until 29 days after the first planting and 22 days after the second. In fact, there occurred at Experiment in 1941 only two ¾-inch rains from April 1 to June 23, covering the period of four plantings. At Laurel the third plantings were made during dry periods; in 1940 it was made 25 days after a ½-inch rain and 11 days before a ½-inch one; in 1941, 34 days before a 1-inch rain; in 1942, 21 days after a 1.6-inch rain; a rain of nearly one-half inch occurred as soon as planting was finished. At Gilmer a more favorable condition occurred with respect to distribution of rainfall than at any of the other locations. There all plantings should have "grown off" satisfactorily and more uniformly than at other locations.

YIELDS

Effect of Time of Planting

Table 2 presents the analysis of variance of the data on total yield and on the yields of the No. 1, No. 2, and Jumbo grades of Porto Rico and Triumph sweetpotatoes for the 3 years and four places combined. This analysis shows that, when compared with the interaction places × years as error, effects due to places for all years were not significant for total

TABLE 2.—*Analysis of variance of total yields and yields of No. 1, No. 2, and Jumbo grades of Porto Rico and Triumph sweetpotatoes grown for 3 years at 4 places in 5 successive plantings with 6 hill spacings*

[Calculated from 5-plot totals in pounds. Conversion formula: pounds per plot × 3.764 = bushels per acre; 55 pounds = 1 bushel]

Source of variation	Degrees of freedom	Variance for—			
		Total	No. 1	No. 2	Jumbo
Places	3	802,039	137,235	545,752	125,371
Years	2	95,447	33,581	9,724	11,865
Places × years	6	247,516	66,880	58,764	38,795
Times	4	1,406,471	241,840	66,941	104,362
Times × places	12	28,678	31,603	20,676	11,323
Times × years	8	21,352	17,294	876	4,553
Times × places × years	24	34,609	15,354	4,586	3,778
Varieties	1	108,109	37,805	6,958	534
Varieties × places	3	185,274	80,602	8,959	17,035
Varieties × years	2	25,668	29,473	4,288	27
Varieties × places × years	6	20,926	282	4,876	6,724
Varieties × times	4	6,968	9,032	2,111	454
Varieties × times × places	12	14,278	14,633	77	1,613
Varieties × times × years	8	8,980	5,034	964	1
Varieties × times × years × places	24	6,923	201	8	345
Spacings	5	123,666	66,336	11,598	29,924
Spacings × places	15	2,390	81	503	2,108
Spacings × years	10	1,558	1,393	389	824
Spacings × years × places	30	1,845	217	208	141
Spacings × times	20	2,167	8,776	612	2,332
Spacings × times × places	60	765	918	47	343
Spacings × times × years	40	629	718	170	45
Spacings × times × years × places	120	592	45	6	45
Spacings × varieties	5	1,014	264	211	80
Spacings × varieties × places	15	1,959	111	26	1
Spacings × varieties × years	10	636	3	1	49
Spacings × varieties × years × places	30	248	59	8	72
Spacings × varieties × times	20	395	10	198	140
Spacings × varieties × times × places	60	1	1,154	590	[1] 5,753
Spacings × varieties × times × years	40	849	329	170	
Remainder	120	95,310	270	651	
Total	719				

[1] For 220 degrees of freedom.

yields and the yields of No. 1 and Jumbo grades. The No. 2 grade, however, shows differences between places that were significant at the 5-percent level. This table also shows that during the years of these experiments for all locations combined the yields did not vary significantly from year to year when compared with places × years as error.

Table 2 further shows that, when compared with the interaction times × places as error, planting time had a highly significant effect upon total yield and the yield of No. 1 and Jumbo grades and a nearly significant effect upon the No. 2 yield. Differences for the cull grade or "strings" (not shown in the table) were not significant. The effect of time of planting was also highly significant for the total yields and all grades when compared with any other first-order interaction involving time. Thus, delay in time of planting reduced significantly and similarly the production of the important grades of sweetpotatoes, regardless of place, variety, year, or spacing in the row. *Time of planting was the most potent single factor observed.*

The data in table 3 show the average yields of the various grades at the first planting time and the successive decreases in yields from each

TABLE 3.—*Effect of planting time on total yield and yields of various grades of sweetpotatoes at 4 places, 1940–42*

[6 spacings and 2 varieties for each place and year; 55 pounds = 1 bushel]

Place and grade	Yield at first planting	Yield per acre decrease for each delay in planting shown compared with the immediately preceding planting[1 2 3]				Place average
		First delay	Second delay	Third delay	Fourth delay	
	Bushels	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*
Blackville, S. C.:						
Total	351	21	21	69*	60	282
No. 1	132	18	−1	15	27	107
No. 2	82	−6	19	10	18	68
Jumbo	91	12	13	33**	24*	56
Experiment, Ga.:						
Total	263	43	46	44	61	171
No. 1	143	52*	8	22	37	80
No. 2	17	6	−5	4	4	13
Jumbo	35	4	14	11	6	18
Laurel, Miss.:						
Total	326	73*	92*	5	66	197
No. 1	208	53*	51*	11	42	122
No. 2	34	1	9	−6	7	29
Jumbo	71	23*	27*	9	9	31
Gilmer, Tex.:						
Total	313	10	33	69*	34	251
No. 1	78	−3	−4	9	15	76
No. 2	152	16	29*	31*	21	105
Jumbo	16	−5	9	7	2	11
All places:						
Total	314	38*	48*	46*	56*	225
No. 1	140	30**	13	14	31**	96
No. 2	71	4	13*	10	12*	54
Jumbo	53	8	16**	15**	10	29

[1] See table 1 for planting dates.

[2] A minus sign indicates a "negative decrease," that is, an increase in yield above the immediately preceding planting.

[3] Least significant difference between planting times at any one place for—	*5-percent level* (*bushels*)	*1-percent level* (*bushels*)
Total yield	69	93
No. 1 yield	45	61
No. 2 yield	25	33
Jumbo yield	22	30
Least significant difference between planting times, mean of all places, for—		
Total yield	34	66
No. 1 yield	23	30
No. 2 yield	12	17
Jumbo yield	11	15

* Significant; ** highly significant.

of the four successive delays in planting time for each place and for all places combined. It also shows the average yield of all planting times by grades for each place and for all places combined.

These data show that at each place there was a successive decrease in total yield for each delay in time of planting. The amount of these losses was not the same at all places for any one delay; nor was it the same for all delays at any one place. Thus, at Blackville, 21 bushels was lost by the first delay, whereas at Experiment the decrease by this delay was 43 bushels; at Laurel it was 73 bushels; and at Gilmer it was only 10 bushels. At Blackville and Gilmer the later delays caused greater losses in total yield than the delays earlier in the season. The reverse was true at Laurel; and at Experiment in these tests there was no great difference between the various planting times in the amount of additional loss for each further delay.

In No. 1 yield these data show that there was considerable variation in response to planting time. There were some delayed planting times at Blackville and Gilmer which produced nonsignificantly more No. 1's than the immediately preceding planting time. At Experiment and Laurel every delay caused a considerable and generally a rather important further decrease in the No. 1 yield. The losses were greater at Laurel than at any other place and greater there in the earlier part of the season. A greater proportion of the yield was No. 1 grade at Laurel than at any other place, and a much lower proportion was produced at Gilmer than at any other place. At Gilmer the yield of No. 1's increased slightly but not significantly at the second and third plantings, and the decreases by the third and fourth delays in planting were small.

The data in table 3 show that the places differed considerably in No. 2 yields. There was a very small proportion of the total yield graded as No. 2 at Experiment, and a very high proportion at Gilmer. At Gilmer the first planting produced about twice as many No. 2's as No. 1's but there was a decrease in yield of No. 2's with each delay in planting time. At Gilmer many roots in the earlier plantings became rough and hence of No. 2 grade. At Laurel the No. 2 yield remained very nearly the same throughout the range of planting times, with all delays showing a small decrease except the third, which showed a small increase. Also at Experiment the delays in planting caused small decreases in No. 2 yield in all cases except the second, when there was a small nonsignificant increase. At Blackville there was a nonsignificant gain in No. 2 yield for the first delay, but decreases of considerable amount resulted from each of the later delays in planting.

In yield of the Jumbo grade the various places were significantly different. The data show that higher yields of Jumbos were made at Blackville and Laurel than at Experiment and Gilmer. They also show there was more reduction in the yield of Jumbos when planting time was delayed at Blackville than at the other places. There was less reduction at Gilmer than at any other place.

The average data for all places combined in table 3 show that for all grades every successive delay in time of planting caused a further decrease in yield. The mean amount of reduction in total yield caused by delaying the planting time was 38 bushels per acre for the first delay, averaging about 18 days; 48 bushels more reduction in yield for the second, averaging 18 days; 46 bushels more reduction for the third delay, averaging about 19 days; and 56 bushels more reduction in yield for the fourth delay, averaging 18 days. Delays of equal length became more serious as they occurred later in the season.

In No. 1 yield the average data show also a reduction with each successive delay in planting time. While the difference between any two successive plantings was not always large enough to be statistically significant, it is important to note that actually 30 bushels of No. 1's to the acre were lost by the first delay in planting. All the loss occurred at Laurel, Experiment, and Blackville. The second delay caused an additional reduction of 13 bushels; the third delay caused an additional reduction of 14 bushels; and the fourth delay was responsible for a still further reduction of 31 bushels. In No. 2 and Jumbo grades each successive delay in planting time caused a reduction in average yield. While some of these reductions were too small to be statistically significant, they were generally large enough to be of considerable importance. It should be noted that as planting time was delayed the proportion of Jumbos to No. 1's decreased very markedly while the proportion of No. 2's to No. 1's tended to increase somewhat. While these proportions are interesting, it is of more importance to the grower to know which planting time should on the average give him the greatest number of bushels of marketable grades to the acre and per unit of labor and equipment.

Cost of production factors undoubtedly vary from place to place within the area of these experiments. Thus, for a complete economic interpretation of these data it will be necessary to compare the yields from the various planting times on the basis of assumed costs involved in the various planting-time practices and on the basis of representative prices for the crop.

The detailed data from these experiments in Mississippi have been interpreted by Anderson and Randolph (*2*) on the basis of profit per acre and production per man-hour. They showed that under the conditions at Laurel not only the highest yield but the greatest net profit per acre was realized from the first planting; the first planting also gave the greatest return in yield per man-hour and the highest value in cents per man-hour. Their data showed that the highest net labor income is to be expected from the earliest planting, that a significant reduction is to be expected for each successive delay in planting time, and that the July planting (the fifth) showed no net labor income.

The interaction times × years (table 2) was not significant for total yield or the yield of any grade, indicating that the effects of time of planting were fairly consistent during the 3 years in which the experiments were carried on. Considering, therefore, that those years were a fair sample of years when sweetpotatoes may be grown, it can reasonably be concluded that similar harmful effects on yields attributable to delay in time of planting can be expected. Table 2 shows that for all grades there was a highly significant variance due to planting time when compared with the interaction times × years as error, indicating a definite 3-year effect of planting dates on yields of all grades despite the fluctuations in response from year to year.

Table 4 presents the average yields of the various grades for each variety at the first planting time and the successive decreases in yields from each of the four successive delays in planting and the average yield for each spacing. These data show that time of planting has a far greater influence upon total yield of both varieties than did hill spacing. At all hill spacings the total yield of Porto Rico and Triumph was reduced successively at each delay in planting by a highly significant amount.

The data for No. 1 yield in table 4 show that in nearly all cases with both varieties there was a significant reduction at each successive delay in planting. With the Porto Rico planted at 8-inch and 42-inch spacings the third delay caused only a 1-bushel decrease in yield. Also at the 32-inch spacing the decrease in No. 1 yield of Porto Rico was not significant at the third delay. It is notable that with this variety there was

TABLE 4.—*Effect of planting time and hill spacing on total yield and yields of No. 1, No. 2, and Jumbo grades of Porto Rico and Triumph sweetpotatoes*

[3 years and 4 places for each variety, spacing, and planting; 55 pounds = 1 bushel]

Variety and hill spacing	Grade	Yield at first planting	Yield per acre decrease for each delay in planting shown compared with the immediately preceding planting [1]				Spacing average
			First delay	Second delay	Third delay	Fourth delay	
Porto Rico:		*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*
8-inch	Total	329	25	62	43	65	242
	No. 1	161	23	38	1	43	111
	No. 2	86	13	17	6	21	59
	Jumbo	23	0	9	8	5	13
12-inch	Total	319	32	47	34	78	236
	No. 1	147	21	22	5	49	105
	No. 2	81	9	19	7	14	57
	Jumbo	36	5	8	15	7	20
16-inch	Total	319	48	48	39	58	225
	No. 1	139	21	21	11	37	98
	No. 2	79	10	18	8	13	54
	Jumbo	50	10	14	13	10	26
24-inch	Total	302	32	72	29	50	212
	No. 1	127	26	18	4	30	88
	No. 2	70	11	1	14	15	52
	Jumbo	57	−2	27	16	11	34
32-inch	Total	286	36	53	28	60	202
	No. 1	111	19	18	2	27	79
	No. 2	60	5	−5	14	22	49
	Jumbo	73	11	22	19	16	40
42-inch	Total	260	32	57	23	54	180
	No. 1	91	18	10	1	28	65
	No. 2	60	8	14	1	11	43
	Jumbo	73	3	29	19	16	42
Triumph:							
8-inch	Total	358	32	50	70	48	265
	No. 1	189	46	23	25	29	123
	Jumbo	22	1	7	12	1	12
12-inch	Total	348	33	69	45	54	251
	No. 1	172	37	11	25	38	118
	Jumbo	37	10	7	15	4	18
16-inch	Total	326	32	28	73	54	244
	No. 1	163	40	4	32	25	111
	Jumbo	45	10	9	15	8	24
24-inch	Total	323	53	39	54	46	226
	No. 1	141	42	2	18	21	95
	Jumbo	65	20	16	14	10	32
32-inch	Total	301	45	38	51	44	213
	No. 1	132	41	−6	27	16	89
	Jumbo	69	26	4	19	14	35
42-inch	Total	280	39	33	47	51	200
	No. 1	110	28	0	20	16	76
	Jumbo	76	11	24	13	20	44

[1] A minus sign indicates a "negative decrease," that is, an increase in yield above the immediately preceding planting.

[2] Least difference required for significance for—

	5-percent level (bushels)	*1-percent level (bushels)*
Total yield	15	19
No. 1 yield	4	5
No. 2 yield	1	2
Jumbo yield	4	5

with all spacings a smaller decrease in No. 1 yield at the third delay than at the other delays in planting. This means that the third and fourth planting times can be expected to yield approximately the same proportion of No. 1 grade Porto Rico under the conditions of these tests, but the yields would be relatively low.

Effect of Spacing

Increasing the hill spacing by 4 inches resulted in significant differences in total yield of the Porto Rico and the Triumph at one planting time in only six comparisons (table 5). With few exceptions, the total yields were slightly lower as the spacing was widened but the successive differences were often too small to be significant. The differences be-

TABLE 5.—*Effect of hill spacing on total yield and yields of No. 1, No. 2, and Jumbo grades of Porto Rico and Triumph sweetpotatoes planted at 5 successive plantings*

[3 years and 4 places for each variety; spacing; and planting; 55 pounds = 1 bushel]

Variety and hill spacing	Grade	Yield per acre for planting shown [1]					Spacing average
		First	Second	Third	Fourth	Fifth	
Porto Rico:		*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*
8-inch	Total	329	304	242	199	134	242
	No. 1	161	138	100	99	56	111
	No. 2	86	73	56	50	29	59
	Jumbo	23	23	14	6	1	13
12-inch	Total	319	287	240	206	128	236
	No. 1	147	126	104	99	50	105
	No. 2	81	72	53	46	32	57
	Jumbo	36	31	23	8	1	20
16-inch	Total	319	271	223	184	126	225
	No. 1	139	118	97	86	49	98
	No. 2	79	69	51	43	30	54
	Jumbo	50	40	26	13	3	26
24-inch	Total	302	270	198	169	119	212
	No. 1	127	101	83	79	49	88
	No. 2	70	59	58	44	29	52
	Jumbo	57	59	32	16	5	34
32-inch	Total	286	250	197	169	109	202
	No. 1	111	92	74	72	45	79
	No. 2	60	55	60	46	24	49
	Jumbo	73	62	40	21	5	40
42-inch	Total	260	228	171	148	94	180
	No. 1	91	73	63	62	34	65
	No. 2	60	52	38	37	26	43
	Jumbo	73	70	41	22	6	42
Triumph:							
8-inch	Total	358	326	276	206	158	265
	No. 1	189	143	120	95	66	123
	Jumbo	22	21	14	2	1	12
12-inch	Total	348	315	246	201	147	251
	No. 1	172	135	124	99	61	118
	Jumbo	37	27	20	5	1	18
16-inch	Total	326	294	266	193	139	244
	No. 1	163	123	119	87	62	111
	Jumbo	45	35	26	11	3	24
24-inch	Total	323	270	231	177	131	226
	No. 1	141	99	97	79	58	95
	Jumbo	65	45	29	15	5	32
32-inch	Total	301	256	218	167	123	213
	No. 1	132	91	97	70	54	89
	Jumbo	69	43	39	20	6	35
42-inch	Total	280	241	208	161	110	200
	No. 1	110	82	82	62	46	76
	Jumbo	76	65	41	28	8	44

[1] See footnote 2, table 4, for least differences required for significance.

tween the 24- and 32-inch and between the 32- and 42-inch spacings were often nonsignificant. These data show that above 8 inches the hill spacing may be widened without greatly affecting the total yields unless the spacing is wider than 24 inches.

The data in table 5 show that with both varieties varying the hill spacing had less effect upon the yield of the No. 1 grade than did varying the planting time. The differences between the spacings at any one planting time were about the same for both varieties. With a few scattered exceptions among the later planting times, the wider the hill spacing the lower the No. 1 yield. Also, with both varieties the later the planting the smaller were the yields and the relative as well as absolute differences between the yields from the different spacings.

At the first two plantings of both varieties each widening of the spacing resulted in a small but significant reduction of No. 1 yield. At the third planting widening the spacing of the Porto Rico from 8 to 12 inches actually resulted in a small increase in No. 1 yield and widening it from 12 to 16 inches caused a small and significant reduction in No. 1 yield, but widening the spacing from 16 to 24 inches caused a highly significant reduction. Widening the spacing from 24 to 32 and from 32 to 42 inches caused further reductions that were significant. With the Triumph at the third planting there was also a small increase in No. 1 yield when the spacing was widened from 8 to 12 inches. The reductions in No. 1 yield from other widening of the spacing were small and highly significant except when the spacing was widened from 24 to 32 inches. At the fourth planting the Porto Rico made the same yield of No. 1's at 8- and 12-inch spacings, but the further widening of the spacing caused successive highly significant reductions in No. 1 yield. With the Triumph at the fourth planting the 12-inch spacing made actually a few more bushels of No. 1's than the 8-inch and the reductions by further widening the spacing were all small and highly significant. At the fifth planting most widenings of the hill spacing caused successive reductions in No. 1 yield, which were very small but significant.

These data show in general that late plantings yield so poorly that any differences due to spacing are necessarily small. Although close spacing gives a slightly larger proportion of No. 1 roots than does wide spacing in the late plantings, heavy losses in yield still result from late planting.

STARCH CONTENT

Table 6 presents the analysis of variance of the data on percentage of starch in the freshly harvested Triumph sweetpotatoes from different planting times and hill spacings. The data for Blackville, Laurel, and Gilmer have been combined in this analysis. Table 7 presents average starch percentages for 3 years at the various places, planting times, and hill spacings.

There was no difference of any significance in the starch content at the three places or in the 3 years when measured against the places × years interaction.[6] The analysis shows that there was a highly significant difference in starch content due to planting time. The data of table 7 show that the difference in starch between the first planting, ranging from April 10 to 25, and the third, ranging from May 10 to June 4, was small; it was not significant. Between either the first or the

[6] Extensive studies of 38 kinds of sweetpotatoes planted about the middle of the planting range at these locations in these years showed a significantly higher mean starch content at Laurel than at Gilmer or Blackville.

third and the fifth plantings, however, there was a highly significant difference of much practical importance. The time of the fifth planting ranged from June 15 to July 13. Comparison of the third and fifth plantings shows that 2.67 percent starch was lost by the delay in planting time. This may seem small, but if yields were the same for the two plantings and amounted to 5 tons of sweetpotatoes per acre, this starch loss would amount to 267 pounds to the acre. This loss, considerable when starch is worth 6 cents a pound, is magnified when consideration is taken of the loss of yield by the same delay. The data in table 4 for Triumph total yields show that there was a loss of 106 bushels per acre, average for all spacings, between the third and fifth plantings. The further loss of 1½ pounds of starch per bushel would seem to make unprofitable the planting of the Triumph variety for starch later than about June 1 in the locations involved here.

Table 6 shows that there was no significant difference in percentage of starch due to spacing of hills when the variance for spacings is compared with the remainder variance as error although it approaches significance. The average data for spacings in table 7 show that actually

TABLE 6.—*Analysis of variance of starch content of No. 1 Triumph sweetpotatoes grown for 3 years at 3 places in 3 successive plantings with 3 hill spacings*

[Calculated from 3-block totals; starch expressed as percentage of fresh weight]

Sources of variation	Degrees of freedom	Variance
Places	2	195.14
Years	2	283.07
Places × years	4	183.22
Times	2	524.54**
Times × years	4	18.40
Times × places	4	6.05
Times × places × years	8	43.11
Spacings	2	27.73
Spacings × places	4	4.43
Spacings × years	4	10.29
Spacings × times	4	5.47
Spacings × times × years	8	13.08
Spacings × places × years	8	6.75
Remainder	24	8.75
Total	89	

** Variance highly significant.

TABLE 7.—*Effect of planting time and hill spacing upon the average starch content of No. 1 Triumph sweetpotatoes, 1940–42*

Item	Starch for planting shown (fresh-weight basis)			Place or spacing average
	First	Third	Fifth	
Place:	*Percent*	*Percent*	*Percent*	*Percent*
Blackville, S. C.	22.60	23.23	20.61	22.15
Laurel, Miss.	24.69	25.03	21.98	23.90
Gilmer, Tex.	24.24	24.06	21.73	23.34
Time average	23.84	24.11	21.44	
Spacing:				
8-inch	23.98	24.72	21.77	23.49
16-inch	23.73	24.05	21.45	23.08
32-inch	23.82	23.55	21.09	22.82

a difference of only about two-thirds of 1 percent of starch was associated with 8- and 32-inch spacings. There was no significant interaction of spacings with times, places, or years. This indicates that insofar as starch content is concerned, the Triumph variety apparently was affected by hill spacing about the same at the different places, in different years, and at different planting times. Table 7 shows consistent effects of spacings for the three different times of planting.

CAROTENE CONTENT

Table 8 presents the analysis of variance of data on carotene content of the Porto Rico variety grown at Laurel for three different planting times and three hill spacings for 1940, 1941, and 1942. The data in table 9 show the average carotene content for the 3 years from the different planting times and hill spacings.

In the analysis it is seen that the variance in carotene content for years was not significantly greater than the variance for blocks within years.

TABLE 8.—*Analysis of variance of carotene content of No. 1 Porto Rico sweetpotatoes grown at Laurel, Miss., for 3 years in 3 successive plantings with 3 hill spacings*

[Carotene as micrograms per gram, dry-weight basis]

Source o variation	Degrees of freedom	Variance
Years	2	8,928.50
Blocks within years	6	3,835.02
Times	2	2,992.01
Times × years	4	3,063 71
Times × blocks within years	12	840.60
Spacings	2	2,907.22**
Spacings × years	4	986.23*
Spacings × times	4	96 33
Spacings × years × times	8	582.31
Remainder (error)	36	241.63
Total	80	

* Variance significant. ** Variance highly significant.

In table 8 it is also shown that the effect of planting time is not significant when referred to the interactions time × years or times × blocks within years as error terms, although it approaches significance when the latter interaction is used as error. Because table 9 shows a decided drop in the carotene content from the third to the fifth planting time and because observations at harvest, substantiated by color photographs, indicated that roots from the fifth planting were strikingly less colored than those from earlier plantings, comparison was made of the single value for the fifth planting with that of each of the other planting times. A calculation after the method of Snedecor (*10*) using the single degree of freedom showed a significant difference. It is apparent that most of the variance shown for times of planting in table 8 lies in the comparison of the fifth planting with one of the others, since the first and third are almost identical in content of carotene. It is noted that also at any one spacing there is no significant difference in carotene of sweetpotatoes from the first and third plantings, but there is considerable difference between those of the fifth and either the first or the third planting at each spacing.

Significant differences in carotene appeared among sweetpotatoes from the different spacings, when the interaction spacings × times, spacings × years × times, or the remainder is used as the error term. Also there was significant interaction between spacings and years, which means that the relative carotene contents associated with different spacings were not the same in the different years. Analysis of the data for individual years showed that differences due to spacings were significantly greater in some years than others. Weather conditions may affect carotene content, and it has been shown by Edmond and Sefick (*5*) that the proportion of nutrients affects color of sweetpotatoes. These factors may have served to influence the carotene-content data presented in this circular.

Table 9 shows that as the hill spacing was widened the carotene content was lower, the difference being significant between sweetpotatoes from the 8-inch and the 32- and the 16-inch spacing, but not between the 16- and 32-inch. The difference associated with the 8- and 16-inch

TABLE 9.—*Effect of planting time and hill spacing on average carotene content of No. 1 Porto Rico sweetpotatoes grown at Laurel, Miss., 1940–42*

Planting	Yield per gram of dry weight from hill spacing			Time average[1]
	8-inch	16-inch	32-inch	
	Micrograms	*Micrograms*	*Micrograms*	*Micrograms*
First	113.0	100.5	92.8	102.1
Third	109.4	97.0	94.4	100.3
Fifth	98.4	75.9	74.7	83.0
Spacing average[1]	106.9	91.1	87.3	

[1] Least difference required for significance between spacing or time averages, 8.6 and between planting times at any one spacing or between spacings at any one planting, 12.7.

spacings was greater than that with the 16- and 32-inch, both in the average of all plantings and at each planting time. At the fifth planting time, the greatest difference occurred between sweetpotatoes from the 8- and 16-inch spacings; the roots from the 16- and the 32-inch spacings were approximately equal in carotene content.

ROOT SHAPE

Table 10 gives the analysis of variance of data on shape index (length to diameter ratio) of sweetpotatoes grown for 3 years at Laurel and Gilmer, at three different times of planting and with three hill spacings. This table shows that there was no significant difference in the shape of roots grown at the two places, when both varieties, all the planting times, and hill spacings are considered together. It also shows that the differences in shape in the 3 years were too small for significance when compared with the places × years interaction. Table 11 presents average data on shape index. It will be seen in this table that the average of all index figures for Laurel was 2.51 and that for Gilmer was 2.57. For all practical purposes, this would indicate that sweetpotatoes grown at the two locations have the same shape. Varieties, however, differ.

The variance analysis shows that the two varieties were highly different in shape, if the variance for the interaction varieties × places × years is used as error. The interactions varieties × places and varieties ×

TABLE 10.—*Analysis of variance of shape index of representative roots of 2 varieties of sweetpotatoes grown for 3 years at 2 places in 3 successive plantings with 3 hill spacings*

Source of variation	Degrees of freedom	Variance
Places	1	0.77
Years	2	13.32
Places × years	2	2.63
Varieties	1	67.69**
Varieties × places	1	6.91**
Varieties × years	2	4.17**
Varieties × places × years	2	.03
Times	2	18.62
Times × places	2	5.03
Times × years	4	3.09
Times × places × years	4	2.75
Times × varieties	2	.81
Times × varieties × places	2	1.53
Times × varieties × years	4	1.58
Times × varieties × places × years	4	1.08
Spacings	2	1.79
Spacings × places	2	1.79
Spacings × years	4	.22
Spacings × places × years	4	.36
Spacings × varieties	2	.43
Spacings × varieties × places	2	1.13
Spacings × varieties × years	4	.31
Spacings × varieties × places × years	4	.28
Spacings × times	4	.59
Spacings × times × places	4	.89
Spacings × times × years	8	.53
Remainder	32	.34
Total	107	

** Variance highly significant.

TABLE 11.—*Effect of planting time and hill spacing on average shape index of representative roots of Porto Rico and Triumph sweetpotatoes grown for 3 years at 2 places in 3 successive plantings with 3 hill spacings*

Item	Index for planting time shown			Place, spacing, or variety average [1]
	First	Third	Fifth	
Place:				
Laurel, Miss.	2.21	2.42	2.90	2.51
Gilmer, Tex.	2.41	2.62	2.67	2.57
Time average	2.31	2.52	2.78	
Spacing:				
8-inch	2.33	2.63	2.89	2.62
16-inch	2.34	2.44	2.66	2.48
32-inch	2.24	2.47	2.80	2.50
Variety:				
Porto Rico	2.00	2.24	2.58	2.27
Triumph	2.61	2.79	2.99	2.80
Porto Rico:				
Laurel, Miss.	1.84	2.12	2.51	2.16
Gilmer, Tex.	2.16	2.35	2.64	2.38
Triumph:				
Laurel, Miss.	2.57	2.70	3.29	2.85
Gilmer, Tex.	2.65	2.88	2.69	2.74

[1] Least significant difference between—	*5-percent level (index)*	*1-percent level (index)*
Varieties	0.05	0.11
Varieties at any one place	.03	.07
Places for any one variety	.03	.07
Times of planting	.68	1.03

years are highly significant. This indicates that the two varieties did not respond alike in the two places or in the 3 years to factors which influenced shape of the roots. In table 11 it is seen that at Laurel there was more difference in the shape of Porto Rico between the early- and late-planted lots than there was between the early- and late-planted lots of this variety at Gilmer. It also appears that Porto Rico was more slender at Gilmer than at Laurel, while with Triumph the reverse was true.

The average data in table 11 show that the two varieties produced roots that were distinctly different in shape; such a difference was to be expected. The indexes of 2.27 for Porto Rico and 2.80 for Triumph indicate that the latter produced roots that were about 25 percent more slender than the former.

There was a significant difference in root shape due to varying the planting times. The differences were significant, when compared with the interaction times × varieties. Both varieties responded virtually alike in this respect.

With both varieties at Laurel the data show significant changes in root shape from chunky to slender as the planting time was delayed. The Porto Rico seemed to be affected more than the Triumph by time of planting. Figure 1 illustrates the difference in shape of the Porto Rico grown by early planting and by late planting

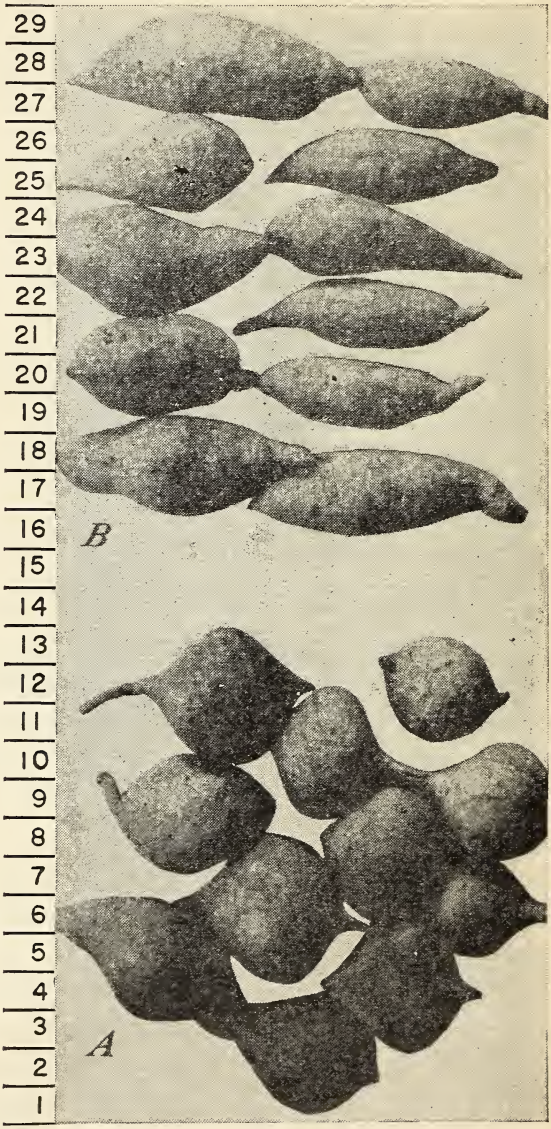

FIGURE 1.—Porto Rico sweetpotatoes grown at Laurel, Miss., in 1940, from plants set out April 24 (*A*) and June 28 (*B*), both dug October 10. (Scale in inches.)

at Laurel. The data do not show such a wide difference in shape from early and late plantings at Gilmer, although the late plantings did yield roots that were significantly more slender than those from the early plantings. The variance analysis shows nonsignificant variances for the interactions times × places, times × years, and times × varieties. The data show that spacing had no appreciable or consistent effect upon the shape of the roots.

SUMMARY AND CONCLUSIONS

Tests were conducted at Blackville, S. C., Experiment, Ga., Laurel, Miss., and Gilmer, Tex., during 1940, 1941, and 1942 to determine the influence of time of planting and of hill spacing upon the yield, grade, root shape, starch content, and carotene content of sweetpotatoes. The results may be summarized as follows.

Delay in time of planting reduced significantly the production of the important grades of sweetpotatoes, regardless of place, variety, year, or spacing in the row. Time of planting was the most potent of any single factor studied.

Although there was at each place a successive decrease in total yield for each delay in planting time, the amount of these decreases was not the same for all places for any one delay or for all delays at any one place. Delays in planting became more serious in reducing total yield when they occurred later in the season. The first delay caused a loss in yield of 38 bushels, the second a further loss of 48, the third 46 more, and the fourth an additional loss of 56 bushels.

The effect of planting time upon the yield of No. 1's varied from place to place, but, taken as a whole, delays tended to cause decreases in No. 1's. This was especially true when the late plantings were compared with the early. Differences between the early and midseason plantings and between the midseason and late were smaller. In yield of No. 1's the earlier delays caused the greater reductions.

Time of planting had a far greater influence upon yields than did hill spacing. Above 8 inches the hill spacing had little effect upon total yield unless it was as wide as 24 inches.

The differences in No. 1 yield due to hill spacings at any one planting time were about the same for both varieties, and in general the wider the hill spacing the lower was the No. 1 yield. At the late plantings the yields were generally so poor that any differences due to spacing were small. Although close spacing gave a slightly larger proportion of No. 1's in late plantings than did wide spacing, heavy reductions in yield still resulted from late planting.

Starch content in the Triumph variety from the late plantings was lower than from the early and midseason plantings. The results show that June 1 is about as late as growers can safely plant this variety for starch. Spacing of the hills did not materially affect the starch content of the sweetpotatoes.

Roots of the Porto Rico variety produced by late planting contained less carotene than those produced by early and midseason planting. Considerable variation occurred in the data on the effect of hill spacing upon carotene content, but in general the roots from the wider spacings were lighter in color.

There were significant changes in root shape from chunky to slender as the planting time was delayed, with the Porto Rico being affected more

than the Triumph. Spacing of the hills had no appreciable or consis ent effect upon the shape of the roots.

LITERATURE CITED

(1) Anderson, W. S., Currey, E. A., Ferris, E. B., and Robert, J. C.
1941. sweetpotato plant spacing. Miss. Agr. Expt. Sta. Bul. 358, 19 pp.
(2) ——— and Randolph, J. W.
1943. sweetpotato production: time of planting and hill spacing studies. Miss. Agr. Expt. Sta. Bul. 378, 22 pp., illus.
(3) Balch, R. T.
1941. rapid determination of starch (root) with sodium hypochlorite. Indus. and Engin. Chem., Analyt. Ed., 13: 246–248.
(4) Beattie, J. H., Boswell, V. R., and McCown, J. D.
1938. sweetpotato propagation and transplanting studies. U. S. Dept. Agr. Cir. 502, 16 pp.
(5) Edmond, J. B., and Sefick, H. J.
1938. studies of certain nutrient deficiency symptoms of the porto rico sweet potato. S. C. Agr. Expt. Sta. Ann. Rpt. 51: 46–52, illus.
(6) Fisher, R. A.
1938. statistical methods for research workers. Ed. 7, rev., 356 pp., illus. Edinburgh and London.
(7) Guilbert, H. R.
1934. determination of carotene as a means of estimating the vitamin a value of forage. Indus. and Engin. Chem., Analyt. Ed., 6: 452–454.
(8) Miller, J. C., and Kimbrough, W. D.
1936. sweet potato production in louisiana. La. Agr. Expt. Sta. Bul. 281, 23 pp., illus.
(9) Price, J. C. C.
1930. the production and storage of sweet potatoes. Miss. Agr. Expt. Sta. Bul. 279, 20 pp., illus.
(10) Snedecor, G. W.
1940. statistical methods applied to experiments in agriculture and biology. Ed. 3, 422 pp., illus. Ames, Iowa.
(11) Woodard, O.
1932. sweet potato culture in the coastal plain of georgia. Ga. Coastal Plain Expt. Sta. Bul. 17, 52 pp., illus.
(12) Zimmerley, H. H.
1934. the effect of plant spacing on the development of sweet potato storage roots. Amer. Soc. Hort. Sci. Proc. 32: 494–497.

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